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Management of Katahdin Hair Sheep

Management of Katahdin Hair Sheep

A thesis submitted in partial fulfillment
of requirements for degree of
Master of Science in Animal Science

by

.

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Lincoln University
Bachelor of Science in Agriculture, 2011

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This thesis is approved for recommendation to the Graduate Council.

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Abstract

The objectives of this research were to determine the effects of different management practices on Katahdin hair sheep performance. For experiment 1, over 2 yr, 5, 0.4-ha pastures were allocated randomly to 1 of 2 grazing treatments: 1) Continuous; or 2) 4-cell rotation. Fifty yearling Katahdin ewes (53 ± 0.7 kg initial BW; 3.3 ± 0.09 initial BCS) were stratified by BW and BCS and allocated randomly to pastures in early May. Grazing d, basal cover, forage quantity or quality did not differ across treatments; however, sampling date effects were detected for forage quantity and quality. Beginning and end of breeding and final BW and FAMACHA[®] scores, ADG, total gain, end breeding and final BCS, number of lambs/ewe exposed, and lamb birth wt did not differ across treatments. Beginning of breeding BCS tended to be greater and lambing rates and frequency of multiple births were greater from continuous compared with 4-cell rotation. In experiment 2, 93 lambs (26 ± 0.5 kg initial BW; 96 d of age) were stratified by litter, BW, sex, and age of dam and were allocated randomly to 1 of 4 treatments 1) Fenceline AM; 2) Fenceline PM; 3) Traditional AM; and 4) Traditional PM for a 14-d weaning period. Behavior was observed at 12, 24, 48, and 72 h post-weaning. Weaning weight, 14-d post-weaning weight, ADG, and total gain did not differ. Vocalizing tended to be greater from fenceline compared with traditional; however, walking rapidly, running, or lying down did not differ. A time effect was detected for vocalizing and lying down. A treatment \times time interaction tendency was observed for standing. Utilizing rotational grazing with Katahdin ewes may increase lambing rates and frequency of multiples births; however, implementing alternative weaning strategies using Katahdin lambs may not increase performance and may negatively affect behavior.

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Dedication

I would like to dedicate my M.S. thesis to my great-grandfather, Thomas Luebbering. Although, I was unable to meet him, he instilled the dedication to hard work that has been passed down to me through my family, along with his love for agriculture. Agriculture has been an influential part in my life and I strongly believe that the emphasis he put on agriculture is why it plays a huge role in my life today.

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Chapter 1

Review of Literature

Introduction

In the United States, sheep production has decreased for the past 50 yr, although sheep cash receipts have increased (Jones 2004; USDA-NASS, 2011c). This situation suggests that there are opportunities for sheep producers to benefit from the implementation of different production management practices, such as alternative grazing schemes and weaning strategies. Variations to traditional grazing methods, such as rotational grazing, have increased in popularity, especially in recent years. Producers can utilize rotational grazing as a way to increase forage utilization and animal carrying capacity, and potentially increase profits. However, little research on rotational grazing has been conducted examining the late spring through summer grazing season using small ruminants, especially Katahdin hair sheep.

Weaning is a typical livestock management practice. However, the weaning process introduces both environmental and social stressors that can negatively impact animal performance (Lefcourt and Elsasser, 1995; Stookey et al., 1997; Meyers et al., 1999; Price et al., 2003; Boland et al., 2008; Knights et al., 2012). Alternative weaning strategies have been reported to positively impact performance (Price et al., 2003; Boyles et al., 2007; Ness et al., 2012) and behavior (Stookey et al., 1997, Price et al., 2003; Boland et al., 2008; Ness et al., 2012) in newly weaned calves, but limited research has been conducted to evaluate alternative weaning strategies with small ruminants, especially sheep. Therefore, this literature review encompasses an overview of the sheep industry, Katahdin hair sheep breed characteristics,

endophyte-infected tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh; E+], alternative grazing methods, and weaning strategies.

Sheep industry

The sheep industry is currently undergoing changes that have caused a decrease in overall production since 1945 (Jones, 2004). Many sheep producers once considered wool as the main product, with meat production being a secondary source of income. The Wool Act of 1954 was designed to help boost the sheep and wool industry and decrease U.S. reliance on imported wool. This act offered sheep producers direct funding for their product and encouraged producers to produce higher quality wool than what was normally produced. Subsequently, in 1994 amendments to the act stopped government subsidies on wool and mohair production. By 2007 wool and mohair production dropped to the lowest values since the 1950's (Canada, 2008). Without government subsidies, the price of wool has continued to drop, which has resulted in reduced economic benefit from wool-type sheep production. Therefore, sheep producers now tend to look for management practices and sheep breeds resulting in a quality meat product with less emphasis on wool production (Jones, 2004). According to the USDA-NASS (2011a) there were 5.53 million sheep in the United States as of January 1, 2011, with Missouri representing 8% percent of the total United States flock; with approximately 81,000 sheep. In 2013 the USDA-NASS (2013b) reported that sheep numbers continued to decrease by 1% to 5.34 million sheep, with Missouri representing 9% percent of the total market with 75,000 sheep. Although, production and sheep numbers are on a downward trend, cash receipts from 2010 indicate that the United States produced 544 million dollars of sheep products. This number is up 22% from 2009, indicating that although the animal numbers and subsequent pounds of product are

decreasing (USDA-NASS, 2011c), the demand for sheep meat and its products are increasing, justifying the need for more research to determine ways to efficiently and effectively raise sheep.

As with most other livestock species, the sheep industry is driven by fairly large operations, mostly consisting of flocks of 100 or more sheep (Jones, 2004). In 2012, sheep operations with numbers ranging from 1-99 total sheep included 93.9% (USDA-NASS, 2013a) of total of sheep producers (USDA-NASS, 2013a). Although, small farms represent the bulk of the total sheep producers, these farms produced only 35.5% of the total product (USDA-NASS, 2013a). Large farms consisting of 100 or more sheep produced 64.5% of the total product in 2013 (USDA-NASS, 2013a). Therefore, due to the relatively large number of sheep being produced by a relatively few producers, implementing management practices that ease and increase overall production is crucial for improving the sheep industry. Also, improving the industry may encourage small producers to expand and/or encourage more producers to incorporate sheep into their farms, thus increasing sheep numbers and expansion of the sheep industry in general.

Katahdin hair sheep

History

Katahdin hair sheep genetics are making a huge impact on the sheep industry. Since their development as a composite breed, they have increased substantially in popularity, especially in recent years (KHSI, 2012). Katahdin hair sheep, named after Mount Katahdin located in Maine, were developed in the late 1950's by Michael Piel as an alternative to traditional sheep breeds that were raised for both wool and meat. Piel wanted a sheep breed that didn't have to be sheared and could make it on a grass-based system and produce a quality meat product. Within

30 yr, the breed was developed into what Piel desired and by 1985 the Katahdin was considered an official breed with its own registry. In 1987, Katahdin Hair Sheep International had 23 members with registered flocks (KHSI, 2012). Since then, membership has increased to 500 members with 75,000 sheep registries as of 2008. In 2001, Katahdin hair sheep were in the top 6 registered sheep breeds in the United States (KHSI, 2012). General characteristics promoted by the breed organization include: moderate size (mature ewe: 57-84 kg; mature ram: 81-114 kg), docility, heat tolerance, low-maintenance, no shearing, and parasite resistance (KHSI, 2012).

Lamb and ewe performance

Katahdin hair sheep provide sheep producers with an alternative to traditional sheep breeds in that they produce a smaller carcass often desired by ethnic consumers. Reported birth weight averages for Katahdin lambs range from 3.4-5.8 kg and are similar to other hair breeds (Dorper crosses and St. Croix; Burke, 2005; Burke and Apple, 2007). Weaning weights for Katahdin wethers were similar to Dorpers, but were higher compared with St. Croix, with average weaning weights of 17.2 and 19.2 kg for forage- and concentrate-offered diets, respectively; however, weaning weights were lower compared with Suffolk (20.6 kg; Burke et al., 2003; Burke and Apple, 2007). Wildeus et al. (2007) reported greater ADG (131 g/d for Kathdins; 117 g/d for St. Croix, and 87 g/d for Barbados Blackbelly), in a 56 d alfalfa hay feeding trial from Katahdin and St. Croix weaned wethers compared with Barbados Blackbelly wethers. In a metabolism study Katahdin lambs had higher digestibilities (NDF, ADF, N, OM, DM) of alfalfa hay compared with Barbados Blackbellys (Wildeus et al., 2007). Slaughter weights were lower from Katahdin (38.4) compared with Suffolk (45.7 kg); however, Katahdin slaughter weights were similar to Dorper (38.4 kg) and were greater than St. Croix lambs (34.2; Burke and Apple 2007). Research also has shown that Katahdin and Barbados Blackbelly

(64.5%) have a higher dressing percentage (65.1%) compared with Dorset (60.6%) and St. Croix (60.6%) wethers; however, *Longissimus* muscle area was smaller in Katahdin, St. Croix, and Barbados Blackbelly compared with Dorset (14.1, 10.1, 12.1, and 17.2 cm², respectively; Horton and Burgher, 1992). Katahdin × Montadale/Rambouillet cross lambs had increased hot carcass weights compared with Montadale/Rambouillet cross lambs (30 kg vs. 29 kg, respectively) and quality grade was similar, but yield grade was higher for Katahdin cross lambs compared with Montadale/Rambouillet lambs when offered a feedlot diet (Schauer et al., 2006). Burke (2005) reported body weights at the beginning of the breeding season and at weaning that were similar, and in some instances higher, for Katahdin compared with other hair breeds. At breeding, body weights ranged from 43.7-60.4 kg and body weights at weaning ranged 54.6-59.4 kg, for mixed-age Katahdin ewes (Burke, 2005).

Reproductive performance

Sheep are known for having multiple births and some breeds are known for breeding “out of season”. Currently, little research has been reported to evaluate reproductive measurements in Katahdin hair sheep; however, when Dorper, Katahdin, and St. Croix’s were evaluated for reproductive performance during the winter (December), spring (April and May), and summer (August and September), winter breeding (>80%) was the most successful time of breeding for all breeds (Burke, 2005). Summer breeding of Katahdin ewes less than 1 yr of age had the lowest pregnancy rate (<20%) across all 3 breeds, and Dorper and Katahdin ewes had the highest pregnancy losses when bred in the spring (>15%; Burke, 2005). Vanimisetti et al. (2007), using data from Katahdin sheep flocks enrolled in the National Sheep Improvement Plan, reported that the number of lambs born ranged from 1-4 lambs with a mean of 1.83 lambs/ewe. Number of lambs/ewe weaned averaged 1.59 and ranged from 0-3. Average weaning weight and total

weaning weight of litters were 21.78 kg and 27.84 kg, respectively (Vanimisetti et al., 2007). Also, Katahdin lamb survival rates from birth to weaning ranged from 91-92.1% (Schwulst and Martin, 1995; Vanimisetti et al., 2007). Therefore, Katahdin ewes can breed out of season; however, winter breeding is the most successful. Also, Katahdin ewes have a high survival rate of lambs till weaning, which can provide a high percentage of lambs born that the producer can market after weaning.

Parasite resistance

Currently, one of the most challenging aspects in the small ruminant industry is parasite control. The overuse and incorrect use of commercial anthelmintics, such as under dosing has led to an increasing resistant population of *Haemonchus contortus*, or commonly, the barber pole worm (Jackson and Coop, 2000). The barber pole worm lives in the abomasum of small ruminants and is a blood-sucking parasite that causes animals to become anemic and ultimately results in death if not properly controlled. Katahdin have been reported to be more parasite resistant than Barbados Blackbelly (Wildeus and Zajac, 2005). While grazing naturally-infected pastures, Barbados Blackbelly sheep had higher fecal egg counts (518 eggs/g average) when compared with Katahdin hair sheep fecal egg counts (242 eggs/g average). Also, Barbados Blackbelly were dewormed more times (7 vs. 2) compared with Katahdin (Wildeus and Zajac, 2005). When Katahdin were compared with Dorset, Dorper, and Caribbean hair sheep, Katahdin had lower fecal egg counts compared with Dorper crosses and Dorset; however they were similar to Caribbean hair sheep (Vanimisetti et al., 2011), thus indicating increase parasite resistance in Katahdin hair sheep.

In general, relatively little research has been completed to evaluate performance, reproductive measurements, and parasite resistance of Katahdin hair sheep, thus, more research needs to be completed to validate the characteristics of Katahdin genetics.

Grazing systems

Continuous grazing

Many types of grazing systems are used by livestock managers. Two major types include continuous and rotational grazing. Traditionally, livestock are managed using a continuous grazing practice. Continuous grazing is simply where animals remain in one large paddock throughout the grazing season. Under continuous grazing, livestock are allowed free access to consume forages that are more preferred and leave forages that are less preferred or undesirable (Sharrow and Krueger, 1979), which can cause excesses in wasted forage (Hammond et al., 1997). Also, this form of grazing management has been reported to decrease percent basal cover and species composition frequency, thus decreasing desirable forage stand persistence (Anderson et al., 1997). Therefore, alternatives to continuous grazing need to be evaluated. One possible alternative to continuous grazing is rotational grazing.

Rotational grazing

Rotational grazing has increased in popularity in recent years because of the added benefits associated with this grazing method. For rotational grazing, producers subdivide a large paddock into several smaller paddocks (Sharrow and Krueger, 1979). These paddocks are usually separated with some form of fence and animals are moved in a rotational fashion throughout the smaller paddocks, based on producer discretion. Reported benefits of rotational grazing include: calmer livestock, better forage persistence and productivity, improved pasture

utilization and less forage waste, and improved return of unused nutrients back to the soil via urine and manure (Ball et al., 2007). When animals are allowed only a certain area, less desirable plants are better utilized and less forage is wasted (Sharrow and Krueger, 1979). Heitschmidt et al. (1987) reported a greater percentage of standing forage crop in a continuously grazed pasture compared with a rotationally grazed pasture; although he concluded that the higher percentage of forage was due to a greater amount of standing dead plant tissue that was not utilized. However, rotationally grazing ewes had increased available forage when compared with continuous grazing in other studies (Warner and Sharrow, 1984; Grigoli et al., 2012). Allowing plants adequate rest after being grazed, especially during the main growing season (early spring through late spring) can result in more available forage being produced (Sharrow, 1983). Mixed results suggest that overall forage quality is not well determined between continuous and rotational grazing (Warner and Sharrow, 1984; Heitschmidt et al., 1987; Bertelsen et al., 1993; Hafley, 1996; Coffey et al., 2005; Marley et al., 2007). Utilizing E+ by using rotational grazing has been reported to have effects on basal cover and minimal effects on forage quality measurements. In a study in cattle, Coffey et al. (2005) did report that percent basal cover decreased in a twice weekly rotation compared with a twice monthly rotation.

Another added benefit to rotational grazing is an increase in overall carrying capacity. An increase in overall gain/ha may result when carrying capacity increases (Bertelsen et al., 1993; Hafley, 1996), although individual animal gains may decrease (Ball et al., 2007). When continuously grazed pastures were compared with a 6-cell and 11-cell rotation system, a 42% increase in stocking rate was observed, thus increasing gain/ha (Bertelsen et al., 1993). Similarly, when ewes were allowed to graze mixed grass and legume pastures after birth along with their lambs, the lambs gained more total body weight in a rotational grazing system

compared with a continuously grazed system, when stocked at a rate of 12 ewes/ha, which was moderately above the recommended stocking rate for sheep (Sharrow and Krueger, 1979). This increase in carrying capacity is most likely contributed to better overall forage utilization and less forage waste.

Although, there are clear benefits associated with rotational grazing, it is also important to evaluate the disadvantages. Determining the appropriate amount of rotations per pasture is a conflicting decision. Deciding how many and the size of the individual paddocks may depend on the layout of the land, position of water sources, and available forage (Ball et al., 2007). Also, rotational grazing has been shown to decrease individual cattle performance (Hafley, 1996). However, conflicting reports on individual animal performance have been reported in sheep indicating that rotational grazing may increase performance compared with continuous grazing (Warner and Sharrow 1984; Marley et al., 2007). Also, milk production has been reported to decrease with the use of rotational grazing from dairy sheep breeds (Grigoli et al., 2012); however, serum total protein and albumin concentrations increased, but serum urea concentrations decreased with the use of rotational grazing, suggesting better N efficiency (Marley et al., 2007). Therefore, rotational grazing may provide producers an effective and alternative grazing practice compared with continuous grazing that has the potential to ultimately increase profits.

Grazing endophyte-infected tall fescue

Endophyte-infected tall fescue, a cool-season perennial bunch grass, is a widely used forage for all livestock species (regardless of grazing system). Approximately, 14 million ha of usable grassland is occupied with E+ (Ball et al., 2003). Endophyte-infected tall fescue has a

symbiotic relationship with the fungus *Neotyphodium coenophialum* (Ball et al., 2003; Malinowski et al., 2000). Without this symbiotic relationship, the success of the plant is decreased. When the endophyte was removed from the plant, plant yield (Bouton et al., 1993) and length of the grazing season decreased (593 and 768 d for non-infected tall fescue and E+, respectively; Hoveland et al., 1983). *Neotyphodium coenophialum* also aids in the persistence of the plant by increasing the plants ability to respond to fertilizer application and tolerate water stress (Arachevaleta et al., 1989; Malinowski et al., 2000).

Likewise, *Neotyphodium coenophialum* would not thrive without the tall fescue plant. The endophyte needs the plant for nutrients and protection (Malinowski et al., 2000). Additionally, without the plant, the fungus would not be able to reproduce as it by disperses reproductive components via the seeds of the tall fescue plant (Ball et al., 2003).

The fungus produces ergot alkaloids that include: lysergic acids (Malinowski et al., 2000), ergonovine, ergocryptine, ergotamine (Hill et al., 2001), ergosine , ergonine, and ergovaline (Bacon et al., 1986; Rogers et al., 2011). Ergovaline represents the highest concentration of ergot alkaloids in the plant and is followed by ergosine and ergonine (Bacon et al., 1986). Concentrations of ergot alkaloids are high during the spring grazing season, decrease in the summer, and spikes to their highest concentrations in autumn months (Rogers et al., 2011). Concentrations of ergot alkaloids can be found in the shoots of plants and seed heads (Ball et al., 2003). When E+ is vegetative, usually in the spring months, reported ergovaline concentrations are low, but as the plant matures concentrations of ergovaline increase (Rogers et al., 2011).

Although, ergot alkaloids contribute to the success of the fescue plant, these ergot alkaloids can have detrimental effects on livestock. Animal performance is greatly affected

when animals are consuming E+. Decreased body weight gain and BCS (Burke and Rorie, 2002; Drewnoski et al., 2009) have been reported in cattle. This decrease in animal performance may be contributed to a decrease in intake when grazing E+ (Rhodes et al., 1991; Aldrich et al., 1993; Nihsen et al., 2004; Realini et al., 2005). Grazing E+ also decreases the animal's ability to dissipate heat, thus decreasing the efficiency of heat transfer (Rhodes et al., 1991; Aldrich et al., 1993) resulting in increased rectal temperatures (Rhodes et al., 1991; Hoveland et al., 1993; Burke et al., 2006). This can cause the animal to have decreased blood flow to the extremities, possibly resulting in the sloughing off of hooves, tails, and ears (Ball et al., 2003).

Reproductive performance also can be affected by grazing E+. Ewes grazing E+ have reduced lambing rates (Burke et al., 2002), and reduced reproductive performance has been reported in cattle (Porter et al., 1992). Finally, allowing animals to consume E+ can cause reduced prolactin concentrations (Schillo et al., 1988; Aldrich et al., 1993; Burke et al., 2006; Drewnoski et al., 2009; Looper et al., 2010) in both cattle and sheep, decreased total cholesterol levels (Burke et al., 2002), and decreased milk production in cattle (Ball et al., 2003). Currently, most of the published work involving grazing E+ has been reported in cattle, thus indicating more research evaluating sheep grazing E+ is needed. Grazing E+ has been reported to have benefits and detrimental effects on both forage quality and persistence along with animal performance, as presented herein. However, limited research has been reported evaluating the effects of E+ on forage and animal performance, using alternative grazing systems with Katahdin hair sheep.

Weaning management

Weaning is a typical management practice in the livestock industry. Simply, weaning is when offspring are separated from their dams. Traditional weaning methods involved abrupt separation of offspring from their dams and involves placement of newly weaned animals in a drylot or other area without visual or audible contact with their dams (Enríques et al., 2011). This form of weaning can be a stressful process on newly weaned animals and negatively impacts performance (Lefcourt and Elsasser, 1995; Meyers et al., 1995; Price et al., 2003; Boyles et al., 2007; and Knights et al., 2012) and behavior (Stookey et al., 1997; Orgeur et al., 1998; Price et al., 2003; Boland et al., 2008, Ness et al., 2012) of these animals during the weaning process. Traditionally weaned calves spend more time walking their pens, experience decreased ADG during the weaning period (Boyles et al., 2007), and have decreased weight gain up to 10 months post-weaning (Price et al., 2003).

Age at weaning and alternative weaning strategies

Small ruminant producers typically wean lambs at approximately 90 d of age, but may wean as early as 30-45 d or as late as several months of age. Age at weaning affects both the animals being weaned and their dams. Lambs weaned at 76 d compared with 183 d had a lower ADG and total gain throughout the weaning period and had higher mortality rates (Knights et al., 2012). Also, in cattle going to feedlot, d on feed is lowered in calves weaned at 215 d compared with calves weaned at 90 and 152 d, and gain:feed decreased inversely with DMI throughout the feedlot period as age at weaning increased (Meyers et al., 1999). Altering the date of weaning can benefit dam performance and reproductive measurements in the subsequent breeding season. Cows that weaned a calf at 90 d of age had higher ADG up the 215 d postpartum and higher BCS

up to 152 d postpartum. Also, weaning at 90 d of age increased pregnancy rates in cows by 18% compared with cows with calves weaned at 152 or 215 d of age (Meyers et al., 1999).

Alternatives to traditional weaning are currently being evaluated to minimize the negative effects associated with the weaning process. Two such alternatives are the use of a nose-clip to prevent nursing and fenceline weaning. Weaning with a nose-clip is a process where an anti-suckling device is placed on each animal prior to weaning. During a pre-weaning adjustment period, animals equipped with a nose-clip spent less time eating and more time lying down compared with traditional weaned calves. However, when calves were weaned using abrupt separation, the calves with nose-clips spent more time eating and less time pacing (Boland et al., 2008). Secondly, fenceline weaning is a weaning method where offspring have nose to nose contact with their dam. This practice has increased in popularity in recent years. With fenceline weaning practices, performance and behavioral measurements have been shown to be positively impacted when compared to traditional weaning strategies in cattle (Price et al., 2003; Boland et al., 2008). Price et al. (2003) reported that fenceline weaned calves had similar performance and behavior measurements as non-weaned calves. Gain during the weaning period (Price et al., 2003; Boyles et al., 2007) was increased for fenceline weaned calves compared with calves that were traditionally weaned (Price et al., 2003; Boyles et al., 2007). Differences in animal performance between fenceline and traditional weaning can be possibly explained by differences seen in behavioral measurements. Traditionally weaned calves spent more time walking and less time lying down (Price et al., 2003). Therefore, traditionally weaned calves had decreased performance during the weaning period. Boyles et al. (2007) showed that feed efficiency was increased in fenceline weaning compared to traditional weaning and reported morbidity decreased by half in pasture fenceline weaning.

In a sheep weaning study evaluating the effects of fenceline weaning on ewes and lambs, Galeana et al. (2007) reported that after separation, more ewes were located <1 m of a fenceline barrier at 24 h after separation compared with 72 h; however, no differences were reported for times/h that lambs were located within 1 m of the fenceline barrier at any observation time (24, 48, or 72 h). Also, fenceline weaned lambs continued to vocalize up to 72 h post-weaning compared with other alternative weaning strategies (Orihuela et al., 2004).

Another variation to minimize the negative effects associated with the weaning process may be the use of different times of day for weaning livestock, such as in the evening. Possible benefits from this weaning time may be associated with allowing offspring to nurse from their dams throughout the day compared with morning weaning and allowing them to do most of their pacing during the coolest part of the day. Little research has been reported evaluating the time of day on weaning performance and behavior measurements. However, Ogunbameru et al. (1992) evaluated the effects on piglet performance using morning and evening weaning times. Piglet performance was greater for the evening weaning and those piglets had a positive ADG by d 3 of the weaning period while piglets weaned in the morning had a negative ADG on d 3. Also, evening-weaned piglets had higher feed intakes compared with morning-weaned piglets. Ness et al. (2012) evaluated performance and behavior by fall-born calves weaned with traditional or fenceline methods in the AM or PM. Average daily gain and total gain were higher from fenceline and PM weaned calves compared with traditional and AM weaned calves. Fenceline and PM weaned calves vocalized less compared with traditional and AM weaned calves. Therefore, fenceline weaning in the evening may positively impact animal performance and behavior, however, this needs to be evaluated in small ruminants, especially Katahdin hair sheep.

Conclusion

Katahdin hair sheep have had an impact in the sheep industry, which may lead to expansion of the sheep industry. Due to the fact that they require no shearing and can be developed on a grass-based system, Katahdins provide an excellent alternative to traditional sheep breeds. However, Katahdins need to be evaluated further on endophyte-infected tall fescue pastures. Also, the benefits associated with rotational grazing and alternative weaning strategies may provide producers with an effective management practice to be implemented into their production systems. Therefore, these production strategies need to be further evaluated in small ruminants.

Chapter 2

Performance by yearling Katahdin ewes grazing toxic tall fescue using either continuous or rotational grazing schemes in late spring through summer

Abstract

Rotational grazing has increased in popularity in recent yr; however, this grazing method has not been well evaluated with Katahdin hair sheep. Therefore, our objective was to evaluate the effects of utilizing continuous or rotational grazing schemes on performance by yearling Katahdin ewes grazing toxic tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh] pastures in late spring through summer. Over 2 consecutive yr, a total of 50 yearling Katahdin ewes (53 ± 0.68 kg initial BW; 3.3 ± 0.09 initial BCS) were stratified by BW and BCS and were allocated randomly to 1 of 5, 0.4-ha E+ pastures representing 1 of 2 grazing treatments: 1) continuous (C; 5 replications) or 2) 4-cell rotation (4R; 5 replications), beginning in early May of each yr. In mid-May, one ram that passed a breeding soundness exam was placed in each pasture for a 40-d breeding season. Basal cover, available forage, in vitro dry matter digestibility (IVDMD), crude protein (CP), and total ergot alkaloid concentrations did not differ ($P \geq 0.19$) across treatments; however, a sampling date effect ($P \leq 0.01$) was detected for available forage, IVDMD, CP, and total ergot alkaloid concentrations. Grazing d, beginning of breeding, end of breeding, and final BW, ADG, and total gain did not differ ($P \geq 0.19$) across treatments. Beginning of breeding BCS tended ($P = 0.10$) to be greater from C compared with 4R ewes. End of breeding and final BCS and the beginning of the breeding season, end of the breeding season, and final FAMACHA[®] scores did not differ ($P > 0.12$) across treatments. Lambing rates and frequency of multiple births were greater ($P \leq 0.04$) from 4R compared with C, but number of lambs/ewe

exposed and lamb birth wt did not differ ($P \geq 0.16$) across treatments. Therefore, utilizing a 4-cell rotational grazing scheme in late spring through summer by yearling Katahdin ewes may not improve forage quantity and quality, ewe performance including BW, BCS, or parasite infestation, or increase number of lambs/ewe exposed, or lamb birth wt, but may increase lambing rates and frequency of multiple births.

Introduction

In recent yr, rotational grazing has increased in popularity as a livestock and forage management practice. Rotational grazing is a process where large pastures are subdivided into smaller individual paddocks with livestock being rotated through the smaller paddocks; whereas with continuous grazing the livestock remain on the same pasture for the duration of the grazing period (Sharrow and Krueger, 1979). Benefits associated with rotational grazing include: better forage utilization and less forage waste (Sharrow and Krueger, 1979; Ball et al., 2007), better forage production and persistence (Sharrow, 1983; Popp et al., 1997), and ultimately greater carrying capacity (Bertelsen et al., 1993). Although, rotational grazing has been reported to decrease individual animal gains (Hafley, 1996; Popp et al., 1997) the increase in stocking rates associated with rotational grazing potentially improves returns to the producer, thus contributing to its popularity. However, limited research is available evaluating rotational grazing with small ruminants, especially utilizing Katahdin hair sheep. Therefore, our objective was to evaluate the effects of continuous or rotational grazing schemes on performance by yearling Katahdin ewes grazing toxic tall fescue pastures through late spring and summer.

Materials and methods

Pasture and treatments

Over 2 consecutive yr, a total of 50 yearling Katahdin ewes (53 ± 0.68 kg initial BW; 3.3 ± 0.09 initial BCS) were stratified by BW and BCS and were allocated randomly to 1 of 5, 0.4-ha pastures on May 5, 2011 and May 7, 2012, respectively, at a stocking rate of 12 ewes/ha. Pastures consisting of predominately toxic tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh; E+] were utilized and allocated randomly in each yr to 1 of 2 grazing treatments: 1) continuous grazing (C; 5 replications); 2) 4-cell rotational grazing (4R; 5 replications). Animals assigned to C were allowed to graze the entire pasture area for the duration of the project. Each 4R pasture was subdivided into four equally-sized (0.1-ha) cells by an electric fence and animals were rotated between cells as to not restrict intake (<1000 kg/ha). Initially, ewes were rotated every 4 d and as the grazing season extended into July and August ewes were rotated every 1 to 2 d.

Pastures were located at Lincoln University's Carver farm in Jefferson City, MO and animal management followed standard farm operating procedures and was approved by the University of Arkansas Animal Care and Use Committee (No.13047). Nitrogen was applied at 56 kg/ha as ammonium nitrate (34-0-0) in the spring of each yr. Phosphorus, potassium, and lime were applied annually to meet soil test requirements as outlined by the University of Missouri Cooperative Extension Service (Buchholz, 2004). Pastures were clipped at the end of May to a 20.32-cm stubble height to maintain available forage.

Animal management

At initiation of the study (14 d prior to the breeding season), a Control Internal Drug Releasing (CIDR[®]; Pfizer Inc., New York, New York, Product No. 036116) device was inserted

intra-vaginally into each ewe. Fourteen d after CIDR[®] insertion, (Yr 1: May 19, 2011; Yr 2: May 21, 2012) each ewe was administered 400 IU of PG 600 (Intervet Inc., Millsboro, DE 19966, Product No. 057174) and each CIDR[®] was removed. At this time ewes were placed back in their respected pastures with a ram that passed a breeding soundness exam, for a 40-d breeding season. In yr 2, after completion of the breeding season, each ram underwent and passed a second breeding soundness exam to ensure each ram was a viable breeder for the duration of the breeding season. Two wk prior to lambing, ewes were vaccinated against *Clostridium Perfringens types C and D* and *Tetnus Toxoid* (Bar-vac[®] CD/T; Boehringer Ingelheim, Inc., St. Joseph, MO).

All ewes had *ad libitum* access to water, sheep mineral (ADM Alliance Nutrition, Inc., Quincy, IL), and each pasture was equipped with a 3 × 4-m shade shelter (Portable Livestock Shelters, Seymour, MO). When animals were rotated between cells their water, mineral, and shade shelters were moved at the same time. Ewes were weighed and BCS (1-5 scale; 1 = healthy; 5 = obese; Russel et al., 1969) were determined at the start and end of the breeding season and at the end of the study. Ewe FAMACHA[®] scores (1-5 scale; 1 = healthy; 5 = severely anemic; Bath et al., 2001), which are indicators of parasite burden and anemia, were assigned at the beginning and end of the breeding season and at the end of the study.

Sample collection and analyses

In October (21, 2011 and 16, 2012), pastures were evaluated for forage species frequency and basal cover by a modified step-point procedure (Owensby, 1973) in 49 locations/ha. Each month for the duration of the project, pastures were evaluated for quantity and quality of available forage. Available forage was estimated at 29 locations/ha using a rising disk meter

(Bransby et al., 1977) by walking in a zig-zag pattern. Calibration samples were taken on each sampling date in 5 locations by clipping forage directly under the disk meter (0.25 m^2) to a 2.5-cm stubble height with hand shears. These samples were placed in brown paper bags and placed in a drying oven at 50°C and dried to a constant weight under forced air. Dry sample weights were converted to kg/ha by multiplying dry weights by 40. These converted weights were then regressed against disk meter heights to determine calibration equations. Forage quality samples of E+ only were taken at the time of disk meter readings with 15 samples collected/ha on each sampling date. Samples for forage quality analyses were placed in plastic zip-lock bags and put in a cooler to stop transpiration until being frozen at -80°C . Samples were lyophilized using a Labconco FreeZone[®] Stoppering Tray Dryer (Labconco Corporation, Kansas City, MO). Following lyophilization, samples were placed back into freezer storage until analysis at a later date.

Forage quality samples were ground using a Willy mill grinder (Arthur H. Thomas, Philadelphia, PA) to pass through a 1-mm screen. Ground fescue samples were analyzed for in vitro dry matter digestibility (IVDMD) using the batch culture method outlined by the Ankom Technology Corporation (Fairport, New York, USA). Samples also were analyzed for total N using the rapid combustion method (AOAC, 1998, Official Method 990.03; Elementar Americas Inc., Mt. Laurel, NJ). Total N values were multiplied by 6.25 to estimate CP. Total ergot alkaloids concentrations were analyzed using the ELISA procedure outlined by Adcock et al. (1997).

Statistical analyses

Forage measurements: Percent basal cover, species composition frequency, and forage quantity and quality were analyzed using the PROC MIXED procedures for repeated measures of analysis of variance (SAS Inst., Inc., Cary, NC); pasture was considered the experimental unit. The repeated measurement for available forage and forage quality was sampling date. The error term for treatment effects was pasture(treatment) and yr was considered a random effect. Interactions between sampling date and treatment were included in the original model; however, if no interactions were detected ($P \geq 0.10$) they were removed from the model and only the main effects were reported. All data are reported as least squares means.

Animal measurements: Performance measurements and number of lambs born/ewe exposed were analyzed using PROC MIXED, and pasture or group of animals was considered the experimental unit. The error term was pasture(treatment) and yr was considered a random effect. Ewe lambing rates and frequency of multiple births were analyzed using the Chi-square procedure of SAS. Frequency of multiple births considered ewes that had two or more lambs within the lambing season. All data are reported as least squares means. Differences referred to as tendencies are those having a P -value between 0.05 and 0.10. All data are reported as least squares means.

Results and discussion

Monthly rainfall data for 2011 and 2012 during the grazing period (May through August) are shown in Table 1. Monthly rainfall averages were inconsistent over the grazing season and were lower than the 30-yr average. Lower reported values can be contributed to the drought that occurred at the study site during the second yr of the project.

Basal cover and species composition frequency

Basal cover did not differ ($P = 0.40$) across treatments which agrees with Popp et al., (1997) who grazed steers on alfalfa-grass pastures using either continuous or rotational grazing treatments with light (1.1 steers/ha) or heavy (2.2 steers/ha) stocking rates. Endophyte-infected tall fescue was the dominating forage representing 73.1% and 74.3% from C and 4R pastures, respectively, but did not differ ($P = 0.89$) across treatments (Table 2). The percentage of cool-season perennial contamination that included orchardgrass (*Dactylis glomerata* L.) did not differ ($P = 0.11$) from 4R compared with C and only represented a minimal percentage of the total forage composition ($\leq 4.3\%$). Cool-season perennial contamination was not found in yr 2 of the study, which could be a result of the drought that occurred at the study site. Pastures were contaminated with warm-season annuals, such as crabgrass (*Digitaria sanguinalis* (L.) Scop) and knotroot foxtail [*Setaria geniculata* (Lam.) Beauv.], and broadleaf weeds that represented 9.4-16.4% of the total forage composition; however, they did not differ ($P \geq 0.37$) across treatments. Cool-season annuals and warm-season perennials were not detected in any treatment pastures across both yr.

Available forage, forage quality, and total ergot alkaloid concentrations

Available forage and forage quality measurements are shown in Table 3. Sampling date \times treatment interactions were not detected ($P \geq 0.10$). Therefore, these data are pooled across sampling date and yr. Available forage, IVDMD, CP, and total ergot alkaloid concentrations did not differ ($P \geq 0.19$) across treatments. Heitschmidt et al. (1987) reported that cattle continuously grazing resulted in a 50% increase in available forage during the grazing season from January through May in yr 2 of their study compared with cattle rotationally grazing, which

disagrees with our present study. Although the authors of that study reported an increase in standing forage, they concluded this to be a result of more dormant forage in the continuous grazed treatment, which subsequently resulted in a decrease in forage quality. In the present study a sampling date effect was detected ($P \leq 0.01$) for all forage quantity and quality measurements (Table 4). Available forage was greater ($P \leq 0.05$) from August compared with all other months, but available forage did not differ ($P \geq 0.34$) between May, June, and July. This increase in available forage during August may be due to stem elongation associated with advancing forage maturity. In vitro dry matter digestibility was greater ($P \leq 0.01$) in May compared with June, July, and August; however, June, July, and August did not differ ($P \geq 0.06$). Crude protein was greater ($P \leq 0.05$) in May compared with all other months, but June and August did not differ ($P = 0.35$) and were greater ($P \leq 0.04$) by 1 or 2 percentage units, respectively compared with July. The decrease in IVDMD and CP over the summer grazing months agrees with others that reported a decrease in E+ forage quality over time (Caldwell et al., 2010; Looper et al., 2010). July and August had a greater ($P \leq 0.04$) total ergot alkaloid concentration compared with May and June, although May and June did not differ ($P = 0.63$). The lower concentration of total ergot alkaloids in May is in contrast with work reported by Rogers et al. (2011). Concentrations of total ergot alkaloids normally follow a pattern of higher concentrations during the spring growing season and then decrease during the summer months, but the concentrations increase again in the autumn months (Rogers et al., 2011). Although, individual ergot alkaloids were not measured in this present study, concentrations of ergovaline may have impacted total ergot alkaloid concentrations. Ergovaline is reported (Bacon et al., 1986) as the dominating ergot alkaloid found in E+ and follows a pattern where concentrations are low in the spring when forage is vegetative, and increase throughout the summer months as

E+ matures (Rogers et al., 2011). Since, total ergot alkaloid concentrations were low in the spring months, this could indicate that ergovaline concentrations were lower at this time and increased as the plant matured during the summer months.

Grazing days and ewe performance

Grazing d did not differ ($P = 0.66$) from 4R compared with C (Table 5), which disagrees with Popp et al. (1997), who reported an increase in grazing d for pastures that were grazed using a rotational grazing scheme with cattle. Ewe BW at the beginning of the breeding season, end of the breeding season, and at the end of the study did not differ ($P \geq 0.66$) across treatments. This agrees with previous work that reported no difference in ewe BW when utilizing rotational compared with continuous grazing with Romney ewes and their lambs yr round; ewe BW ranged from 47-55 kg for both treatments (Sharrow and Krueger, 1979). Body condition scores at breeding (2 wk after initiation of study) tended ($P = 0.10$) to be greater from C compared with 4R; however, ewe BCS did not differ ($P \geq 0.44$) at the end of the breeding season or at the end of the study across treatments. FAMACHA[®] scores at the beginning of breeding, end of breeding, and at end of the study did not differ ($P \geq 0.12$) across treatments. FAMACHA[®] scores are evaluated on a 1-5 scale (1 = healthy; 5 = severely anemic) and are used as an indication of parasite burden. Since FAMACHA[®] scores ranged from 1.0-1.3 in this study, parasite infestation did not seem to negatively impact animal performance across both treatments. Additionally, ADG and ewe total gain did not differ ($P \geq 0.19$) from 4R compared with C.

Lambing rates from 4R were 32 percentage units higher ($P = 0.03$) compared with C. Overall, lambing rates in this study were greater than those reported by Burke (2005) who saw an approximately 42% overall lambing rate from 1-2-yr old Katahdin ewes grazing E+ during the

spring breeding season (April-May). Number of lambs born/ewe exposed did not differ ($P = 0.11$) across treatments (0.8 vs. 1.6 from C vs. 4R, respectively) which agrees with Sharrow and Krueger (1979) whom reported no difference in number of lambs born alive/ewe exposed in Romney sheep grazing using either continuous or rotational grazing schemes. Frequency of multiple births were higher ($P = 0.04$) from 4R compared with C. Rotationally grazing ewes had a 28 percentage unit increase in multiple births compared with C. Lamb birth weights did not differ ($P = 0.42$) from 4R compared with C, which agrees with previous work reported on either continuously or rotationally grazed sheep (Sharrow and Krueger, 1979). Also, a sex effect on lamb birth weights was not detected ($P = 0.23$) and a treatment \times sex interaction was not detected ($P = 0.91$) for lamb birth weights.

In summary, implementing rotational grazing with Katahdin hair sheep under the suggested stocking rate of 12ewes/ha did not positively influence basal cover, forage quantity or quality, or animal performance. However, rotational grazing may increase lambing rates and frequency of multiple births, thus increasing the number of lambs producers are able to sell and ultimately increasing profits.

Table 1. Precipitation (mm) in Jefferson City, MO during the grazing period (May-August) over 2 yr

Month	Year ^a		Average ^b
	2011	2012	
May	170	46	137
June	170	41	125
July	50	69	114
August	84	25	105

^a Monthly rainfall average for 2011 and 2012 (DNR, 2013).

^b Monthly rainfall averages from 1981-2010 (NOAA, 2013).

Table 2. Basal cover and species composition from endophyte-infected tall fescue pastures grazed using either continuous or 4-cell rotational grazing schemes by yearling Katahdin ewes

Item	Treatment ^a		SEM ^b	P-Value
	C	4R		
Basal cover, %	21.0	25.1	11.17	0.40
Species composition, % of plant species ^b				
Fescue, %	73.1	74.3	6.07	0.89
Cool-season perennials, % ^d	4.3	0.0	2.77	0.11
Warm-season annuals, % ^e	11.8	9.4	6.52	0.68
Broadleaf weeds, %	11.1	16.4	6.61	0.37

^a C = Continuous; 4R = 4-cell rotation.

^b SEM = Pooled standard error of the mean.

^c Cool-season annuals and warm-season perennials were not detected.

^d Includes orchardgrass (*Dactylis glomerata* L.).

^e Includes crabgrass (*Digitaria sanguinalis* (L.) Scop) and knotroot foxtail [*Setaria geniculata* (Lam.) Beauv.].

Table 3. Effects of continuous or 4-cell rotational grazing schemes on forage quantity and quality (DM basis) by yearling Katahdin ewes

Item	Treatment ^a		SEM ^b	<i>P</i> -Value
	C	4R		
Available forage, kg/ha	3430	3605	157.5	0.45
IVDMD, %	58	59	6.3	0.53
CP, %	11	12	1.3	0.19
Total ergot alkaloids, µg/kg	208	219	108.1	0.72

^a C = Continuous; 4R = 4-cell rotation.

^b SEM = Pooled standard error of the mean.

Table 4. Sampling date effects on available forage and forage quality over 2 yr from continuous or 4-cell rotational grazing schemes

Item	Month				SEM ^a
	May	June	July	August	
Available forage, kg/ha	3259 ^c	3396 ^c	3316 ^c	4100 ^b	144.1
IVDMD, %	70 ^b	58 ^c	54 ^c	54 ^c	6.4
CP, %	14 ^b	11 ^c	9 ^d	10 ^c	1.3
Total ergot alkaloids, µg/kg	134 ^c	154 ^c	313 ^b	253 ^b	110.4

^a SEM = Pooled standard error of the mean.

^{b-d} Means in a row without common superscripts differ ($P \leq 0.05$).

Table 5. Performance measurements and grazing d by yearling Katahdin ewes grazing endophyte-infected tall fescue pastures using either a continuous or 4-cell rotational grazing scheme

Item	Treatment ^a		SEM ^b	P-Value
	C	4R		
Grazing d	73	92	16.8	0.66
BW, kg				
At breeding	55	54	2.6	0.66
End of breeding	57	57	3.2	0.83
End of study	60	60	4.6	0.66
BCS ^c				
At breeding	3.5	3.1	0.37	0.10
End of breeding	3.3	3.2	0.24	0.44
End of study	3.1	3.1	0.10	0.45
FAMACHA ^{®d}				
At breeding	1.3	1.1	0.14	0.17
End of breeding	1.2	1.0	0.06	0.12
End of study	1.2	1.2	0.10	0.79
ADG, kg/d	0.07	0.07	0.015	0.48
Total gain, kg	6	7	2.0	0.19
Lambing rate, % ^e	48	80	-	0.03
Number of lambs/ewe exposed	0.8	1.6	0.31	0.11
Frequency of multiple births, % ^e	28	56	-	0.04
Lamb birth wt, kg	3	3	0.3	0.42

^a C = Continuous; 4R = 4-cell rotation.

^b SEM = Pooled standard error of the mean.

^c 1-5 scale; 1 = healthy; 5 = obese (Russel et al., 1969).

^d 1-5 scale; 1 = healthy; 5 = severely anemic (Bath et al., 2001).

^e Analyzed using Chi-square procedure of SAS.

Chapter 3

Performance by spring-born Katahdin lambs weaned using traditional or fenceline weaning methods in the morning or evening

Abstract

Weaning is a commonly used livestock management practice; however, many stressors are involved with the traditional weaning process that can negatively impact animal performance and behavior. Alternative weaning methods and weaning times may be possible solutions to minimize these negative effects. The objective of this study was to determine the effects of traditional vs. fenceline weaning and the time of day weaning is initiated on spring-born Katahdin lamb performance and behavior. Ninety-three spring-born Katahdin lambs (26 ± 0.47 kg initial BW; 96 d of age average) from 56 ewes were stratified by litter, BW, sex, and age of their dam and allocated randomly to 1 of 8 groups prior to weaning. On May 15, 2012, lambs were removed from their dams and groups were assigned randomly to 1 of 4 treatments consisting of: 1) Fenceline AM (FAM; 2 replications); 2) Fenceline PM (FPM; 2 replications); 3) Traditional AM (TAM; 2 replications); and 4) Traditional PM (TPM; 2 replications) for a 14-d weaning period. Behavioral measurements were taken for 10 min per pen at 12, 24, 48, and 72 h post-weaning. Weaning weight and 14-d post-weaning weight, ADG, and total gain did not differ ($P \geq 0.55$) across treatments. Percentage of lambs vocalizing tended ($P = 0.09$) to be greater from fenceline weaned lambs compared with traditionally weaned lambs. Percentages of animals walking rapidly, running, and lying down did not differ ($P \geq 0.36$) across weaning treatments. A time effect was detected ($P \leq 0.03$) for percentage of lambs vocalizing and lying down. A treatment \times interaction tendency ($P = 0.07$) was observed for percentage of lambs

standing. Therefore, utilizing alternative weaning strategies or times may not improve animal performance by spring-born Katahdin lambs and may have minimal negative effects on lamb behavior.

Introduction

Negative effects on animal performance (Lefcourt and Elsasser, 1995; Meyers et al., 1999; Price et al., 2003; Boyles et al., 2007; Knights et al., 2012) and behavior (Stookey et al., 1997; Price et al., 2003; Boland et al., 2008; Ness et al., 2012) have been associated with the weaning process. Traditionally, the weaning process is initiated by abruptly separating offspring from their dams and placing them in a drylot away from their dams without visual or audible contact (Enríques et al., 2011). In recent yr, alternative management strategies, such as fenceline weaning and the use of anti-sucking devices, have increased in popularity. Fenceline weaning is a management practice where offspring are separated from their dams by some form of a barrier that allows the animals to have nose to nose contact with their dams. When compared with traditional weaning, fenceline weaning may positively affect animal gain (Price et al., 2003; Boyles et al., 2007; Ness et al., 2012) and behavior (Stookey et al., 1997; Price et al., 2003; Boland et al., 2008; Ness et al., 2012). Another alternative weaning strategy that may be utilized is the time weaning is initiated, such as weaning in the evening compared with weaning in the morning. Evening weaning may increase pig performance and feed intake (Ogunbameru et al., 1992) and increase cattle performance and improve behavior (Ness et al., 2012). Using fall-born calves, Ness et al. (2012) evaluated the effects of alternative weaning strategies and times. It was observed that calf ADG and total gain was improved and percentage of calves vocalizing was lower with fenceline and evening weaning strategies. However, little information is available on the effects of these weaning management practices and times in sheep. Therefore,

the objective of this study was to determine the effects of weaning method and time of day weaning is initiated on spring-born Katahdin lamb performance and behavior.

Materials and methods

Animal management:

This study was conducted at Lincoln University Carver Farm located in Jefferson City, MO and animal management followed standard farm operating procedures and was approved by the University of Arkansas Animal Care and Use Committee (No.13047). Fifty-six Katahdin ewes and their spring-born lamb progeny ($n = 93$; 26 ± 0.47 kg initial BW; 96 d of age average) were used in a 2×2 factorial design to determine the effects of weaning strategy and the time of day weaning was initiated. Lambs were stratified by litter, BW, sex, and age of their dam and allocated randomly to 1 of 8 groups prior to weaning. At initiation of the weaning period (May 15, 2012), lambs were removed from their dams, vaccinated against *Clostridium Perfringens* types C and D and Tetanus Toxoid (Bar-vac[®] CD/T; Boehringer Ingelheim, Inc., St. Joseph, MO), dewormed (Cydectin[®]; Boehringer Ingelheim, Inc., St. Joseph, MO), and groups were assigned randomly to 1 of 4 weaning treatments representing: 1) Fenceline AM (FAM; 2 replications); 2) Fenceline PM (FPM; 2 replications); 3) Traditional AM (TAM; 2 replications); and 4) Traditional PM (TPM; 2 replications) for a 14-d weaning period. Morning weaning occurred at 0730 h and PM weaning was at 1730 h. Fenceline weaned lambs had access to 0.1-ha paddocks, consisting predominantly of endophyte-infected tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh], adjacent to their dams. Each replication of traditionally weaned lambs was housed in a 37.2 m² drylot away from their dams and had access to medium-quality tall fescue hay (61% IVDMD and 10% CP). All lambs had *ad libitum* access to water and trace mineral (ADM

Alliance Nutrition, Inc., Quincy, IL), and were offered a grain-based supplement (16% CP) at 2% BW (as-fed) for the duration of the 14-d weaning period. Lambs were weighed at the end of the weaning period and were revaccinated. Behavior measurements were observed and recorded at 12, 24, 48, 72 h post-weaning. Over a 10-min period, groups were observed to determine if each individual lamb, at least once exhibit any of the following measurements: vocalized, walked rapidly, was running at a quick speed throughout their pen, was standing, or was lying down. Lambs were only recorded once if they were observed to exhibit any of the aforementioned behavior measurements. Pen averages for each behavior measurement were calculated by dividing the number of lambs that exhibited the behavior by the total number of lambs in the pen and was multiplied by 100; this was done to determine the percentage of lambs that exhibited each behavior at each observation time.

Statistical analyses

Lamb performance were analyzed using the PROC MIXED procedure of SAS (SAS Inst., Inc., Cary, NC) with group of animals considered the experimental unit and pen(treatment) was used as the error term. Sire(pen) was in the random statement to remove sire variation. Three preplanned orthogonal contrast statements were used: 1) the mean of fenceline weaning compared with the mean of traditional weaning; 2) the mean of AM weaning compared with the mean of PM weaning; 3) and their interactions. Treatment means are reported as least squares means.

Behavioral measurements were analyzed using the PROC MIXED procedures for repeated measures of analysis of variance with group of animals considered the experimental unit and observation time considered the repeated measurement. The same orthogonal contrast

statements as stated above were used to evaluate behavior. If a treatment \times time interaction was observed then means were separated using the F-protected *t*-test and all treatment means were reported as least squares means. Differences referred to as tendencies have a *P*-value between 0.05-0.10.

Results and discussion

Weaning weight, 14-d weight, ADG, and total gain for the duration of the 14-d weaning period did not differ ($P \geq 0.55$) across treatments (Table 6). In a study with cattle, Ness et al. (2012) reported comparable findings for weaning weight and 14-d weight; however PM (1.2 kg/d) and fenceline (1.2 kg/d) weaned calves had higher ADG and total gain over the weaning period compared with AM (0.66 kg/d) and traditional (0.72 kg/d) weaning. Similarly, comparing fenceline with traditional weaning in cattle, others have reported an increase in animal performance (Price et al., 2003; Boyles et al., 2007). Also, PM weaning has been reported (Ogunbameru et al. 1992) to positively impact pig performance with PM weaned pigs having a 6% increase in ADG compared with AM weaned pigs; however similar results in sheep were not found in our study, thus indicating that the weaning period might not be as stressful on sheep compared with other livestock species.

Percentage of lambs vocalizing did not differ ($P = 0.29$) across treatments (Table 7). Fenceline weaned lambs tended ($P = 0.09$) to vocalize more compared with traditional weaned lambs; however, percentage of lambs vocalizing did not differ ($P = 0.56$) from AM compared with PM, which disagrees with Ness et al. (2012) whom reported that the percentage of calves vocalizing were greater from traditionally weaned calves compared with fenceline weaned calves (63 vs. 47%, respectively) and calves weaned in the AM vocalized more compared with PM

weaned calves (67 vs 42%, respectively). Weaning treatment had no effect ($P \geq 0.36$) on the percentage of lambs walking rapidly, running, or lying down during the 10-min observational period, which disagrees with previous work completed on cattle (Price et al., 2003). In that study, fenceline weaned calves walked less (10.1 vs. 17.5%, respectively) and laid down more (23.3 vs. 19.5%, respectively) compared with traditionally weaned calves on pasture or in a drylot (Price et al., 2003). A time effect was detected ($P = 0.01$) with lambs vocalizing more at 12 and 24 h compared with 48 and 72 h (Table 8). This agrees with Orihuela et al. (2004) who reported that vocalization rate was highest at 24 h after weaning in fenceline weaned lambs. Also, a time effect was detected ($P = 0.03$) with more lambs lying down at 24, 48, and 72 h compared with 12 h (Table 3). A weaning strategy and weaning time interaction tendency ($P = 0.06$) was detected for percentage of lambs standing and a treatment \times time interaction tendency ($P = 0.07$) was detected with FAM lambs having the lowest percentage of lambs standing at 24 h (Table 9). Therefore, lamb behavior during the weaning period may not be as improved by alternative weaning strategies and time of weaning as seen in other livestock species.

Conclusion

Based on these results, lamb performance may not be improved when utilizing alternative weaning strategies such as fenceline or PM weaning times. Additionally, alternative weaning strategies may negatively affect lamb behavior. Considering the advantageous findings in earlier research with cattle that were fenceline weaned in the evening, when compared with the current study, it appears that sheep respond differently during the weaning process.

Table 6. Performance by spring-born Katahdin lambs weaned in the morning or evening using either fenceline or traditional weaning strategies

Item	Treatment ^a				SEM ^b	Contrast ^c
	FAM	FPM	TAM	TPM		
Weaning wt., kg	26	25	26	26	1.4	NS
14-d post-weaning wt., kg	30	29	30	29	1.3	NS
ADG, kg	0.3	0.3	0.3	0.2	0.03	NS
Total gain, kg	4	4	4	3	0.5	NS

^a FAM = Fenceline AM; FPM = Fenceline PM; TAM = Traditional AM; TPM = Traditional PM.

^b SEM = Pooled standard error of the mean.

^c Contrast: NS = No significant difference ($P > 0.05$).

Table 7. Behavioral measurements by spring-born Katahdin lambs weaned in the morning or evening using either fenceline or traditional weaning strategies

Item	Treatment ^a				SEM ^b	Contrast ^c
	FAM	FPM	TAM	TPM		
Vocalization, %	26	24	16	11	0.4	w
Walking rapidly, %	3	2	0	1	1.9	NS
Running, %	10	1	0	1	5.2	NS
Lying down, %	46	37	27	44	7.1	NS
Standing, %	73	88	96	82	5.5	y

^a FAM = Fenceline AM; FPM = Fenceline PM; TAM = Traditional AM; TPM = Traditional PM.

^b SEM = Pooled standard error of the mean.

^c Contrast: w = Mean of fenceline weaned lambs compared with the mean of traditional weaned lambs tendency ($P = 0.09$); y = Mean of fenceline AM & traditional PM weaned lambs compared with the mean of fenceline PM & traditional AM weaned lambs tendency ($P = 0.06$); NS = No significant difference ($P > 0.05$).

Table 8. Observation time effect from spring-born Katahdin lambs weaned in the morning or evening using either fenceline or traditional weaning strategies

Item	Observation Time ^a				SEM ^b
	12	24	48	72	
Vocalization, %	30 ^c	27 ^c	15 ^d	4 ^d	5.4
Lying down, %	20 ^d	52 ^c	40 ^c	42 ^c	7.2

^a Behavior measurements were observed for 10 min and were recorded at 12, 24, 48, and 72

post-weaning for each pen.

^b SEM = Pooled standard error of the mean.

^{c-d} Means within a row without common superscript differ ($P \leq 0.05$).

Table 9. Percentage of spring-born Katahdin lambs standing after weaned in the morning or evening using either fenceline or traditional weaning strategies at 12, 24, 48, and 72 h post-weaning

Observation time	Treatment ^a			
	FAM	FPM	TAM	TPM
12	96 ^b	79 ^{bc}	100 ^b	100 ^b
24	36 ^d	91 ^{bc}	100 ^b	66 ^c
48	90 ^{bc}	87 ^{bc}	87 ^{bc}	83 ^{bc}
72	68 ^d	91 ^{bc}	96 ^b	79 ^{bc}

^a FAM = Fenceline AM; FPM = Fenceline PM; TAM = Traditional AM; TPM = Traditional PM.

^{b-c} Means without common superscript differ ($P \leq 0.10$).

Conclusion

Based on the results in experiment 1, implementing rotational grazing schemes by Katahdin hair sheep producers may have a positive impact on the sheep industry. Due to the fact that lambing rates and frequency of multiple births were increased using rotational grazing may result in more products for lamb producers to market, thus increasing profits. Also, the increase in marketed sheep products may aid in meeting the increased demand of sheep products. However, as reported in experiment 2, using alternative weaning strategies may not increase lamb performance, thus indicating that traditional weaning methods are suitable for weaning spring-born Katahdin lambs.

Literature cited

- Adcock, R. A., N. S. Hill, J. H. Bouton, H. R. Boerma, and G. O. Ware. 1997. Symbiont regulation and reducing ergot alkaloid concentration by breeding endophyte-infected tall fescue. *J. Chem. Ecol.* 23:691-704.
- Aldrich, C. G., J. A. Paterson, J. L. Tate, and M. S. Kerley. 1993. The effects of endophyte-infected tall fescue consumption on diet utilization and thermal regulation in cattle. *J. Anim. Sci.* 71:164-170.
- AOAC. 1998. Official Methods of Analysis. 16th. Ed. Assoc. Of. Anal. Chem. Gaithersburg, MD.
- Anderson, B., M. Trammell, T. J. Klopfenstein. 1997. Continuous vs. rotational stocking of warm-season grasses at three stocking rates. Nebraska Beef Cattle Reports. Paper 428.
- Arachevaleta, M., C. W. Bacon, C. S. Hoveland, and D. E. Radcliffe. 1989. Effect of the tall fescue endophyte on plant responses to environmental stress. *Agron. J.* 81:83-90.
- Bacon, C. W., P. C. Lyons, J. K. Porter, and J. D. Robbins. 1986. Ergot toxicity from endophyte-infected grasses: a review. *Agron. J.* 78:106-116.
- Ball, D. M., C. S. Hoveland, and G. D. Lacefield. 2007. Southern Forages. 4th ed. International Plant Nutrition Institute, Norcross, GA.
- Ball, D. M., S. P. Schmidt, G. D. Lacefield, C. S. Hoveland, and W. C. Young, III. 2003. Tall fescue/endophyte concepts. Oregon Tall Fescue Commission Special Publication 1-03, Salem, OR.
- Bath, G. F., J. W. Hansen, R. C. Krecek, J. A. van Wyk, and A. F. Vatta. 2001. Sustainable approaches for managing *Haemonchosis* in sheep and goats. FOA Animal Production and Health Paper, Final report of FAO Technical Co-operation Project No. TCP/SAF/8821(A).
- Bertelsen, B. S., D. B. Faulkner, D. D. Buskirk, and J. W. Castree. 1993. Beef cattle performance and forage characteristics of continuous, 6-paddock, and 11-paddock grazing systems. *J. Anim. Sci.* 71:1381-1389.
- Boland, H. T., G. Scaglia, W. S. Swecker, Jr., and N. C. Burke. 2008. Effects of alternate weaning methods on behavior, blood metabolites, and performance of beef calves. *Prof. Anim. Sci.* 24:539-551.
- Bouton, J. H., R. N. Gates, D. P. Belesky, and M. Owsley. 1993. Yield and persistence of tall fescue in the southeastern coastal plain after removal of its endophyte. *Agron. J.* 85:52-55.

- Boyles, S. L., S. C. Loerch, and G. D. Lowe. 2007. Effects of weaning management strategies on performance and health of calves during feedlot receiving. *Prof. Anim. Sci.* 23:637-641.
- Bransby, D. I., A. G. Matches, and G. F. Krause. 1977. Disk meter for rapid estimation of herbage yield in grazing trials. *Agron. J.* 69:393-396.
- Buchholz, D. D. 2004. Soil test interpretations and recommendations handbook. Coop. Ext. Service. and University of Missouri, Columbia, MO.
- Burke, J. M. 2005. Lamb production of Dorper, Katahdin, and St. Croix bred in summer, winter, or spring in the United States. *Sheep and Goat Res. J.* 20:51-59.
- Burke, J. M. and J. K. Apple. 2007. Growth performance and carcass traits of forage-fed hair sheep wethers. *Small Rumin. Res.* 67:264-270.
- Burke, J. M., J. K. Apple, W. J. Roberts, C. B. Boger, and E. B. Kegley. 2003. Effect of breed-type on performance and carcass traits of intensively managed hair sheep. *Meat Sci.* 63:309-315.
- Burke, J. M., C. Bishop, and F. Stormshak. 2006. Reproductive characteristics of endophyte-infected or novel tall fescue fed ewes. *Livest. Sci.* 104:103-111.
- Burke, J. M. and R. W. Rorie. 2002. Changes in ovarian function in mature beef cows grazing endophyte infected tall fescue. *Theriogenology.* 57:1733-1742.
- Burke, J. M., W. G. Jackson, and G. A. Robson. 2002. Seasonal changes in body weight and condition, and pregnancy and lambing rates of sheep on endophyte-infected tall fescue in the south-eastern United States. *Small Rumin. Res.* 44:141-151.
- Caldwell, J. D., K. P. Coffey, W. K. Coblenz, J. A. Jennings, D. S. Hubbell III, D. L. Kreider, M. L. Looper, D. L. Galloway, E. B. Kegley, and C. F. Rosenkrans Jr. 2010. Weaning and post-weaning performance by fall-born calves weaned on different dates in the spring from *Neotyphodium coenophialum*-infected tall fescue pastures. *Livest. Sci.* 135:44-52.
- Canada, C. 2008. Wool and mohair price support. Congressional Research Service-The Library of Congress. <<http://www.nationalaglawcenter.org/assets/crs/RS20896.pdf>>. Accessed 7 August 2013.
- Coffey, K. P., W. K. Coblenz, D. A. Scarbrough, J. B. Humphry, B. C. McGinley, J. E. Turner, T. F. Smith, D. S. Hubbell III, Z. B. Johnson, D. H. Hellwig, M. P. Popp, and C. F. Rosenkrans, Jr. 2005. Effect of rotation frequency and weaning date on forage measurements and growth performance by cows and calves grazing endophyte-infected tall fescue pastures overseeded with crabgrass and legumes. *J. Anim. Sci.* 83:2684-2695.

- DNR. 2013. Monthly Total Precipitation across Missouri. Missouri Department of Natural Resources. Water Resources Center, Jefferson City, MO.
- Drewnoski, M. E., E. J. Oliphant, M. H. Poore, J. T. Green, and M. E. Hockett. 2009. Growth and reproductive performance of beef heifers grazing endophyte-free, endophyte-infected and novel endophyte-infected tall fescue. *Livest. Sci.* 125:254-260.
- Enríques, D. M., J. Hotzel, and R. Ungerfeld. 2011. Minimising the stress of weaning of beef calves: a review. *Acta Veterinaria Scandinavica.* 53:28-35.
- Galeana, L., A. Orihuela, V. Aguirre, r. Vazquez. 2007. Mother-young spatial association and its relation with proximity to a fence separating ewes and lambs during enforced weaning in hair sheep (*Ovis aries*). *Appl. Anim. Behav. Sci.* 108:81-88.
- Grigoli, A. D., M. Tordaro, G. D., Miceli, V. Genna, G. Tornambe., M. L. Alicata, D. Giambalvo, A. Bonanno. Effects of continuous and rotational grazing of different forage species on ewe milk production. *Small Rumin. Res.* 106S:S29-S36.
- Hafley, J. L. 1996. Comparison of Marshall and Surrey ryegrass for continuous and rotational grazing. *J. Anim. Sci.* 74:2269-2275.
- Hammond, A. C., M. J. Williams, T. A. Olson, L. C. Gasbarre, E. A. Leighton, and M. A. Menchaca. 1997. Effect of rotational vs continuous intensive stocking of bahiagrass on performance of Angus cows and calves and interaction with sire type on gastrointestinal nematode burden. *J. Anim. Sci.* 75:2291-2299.
- Heitschmidt, R. K., S. L. Dowhower, and J. W. Walker. 1987. Some effects of a rotational grazing treatment on quantity and quality of available forage and amount of ground litter. *J. of Range Manage.* 40: 318-321.
- Hill, N. S., F. N. Thompson, J. A. Stuedemann, G. W. Rottinghaus, H. J. Ju, D. L. Dawe, and E. E. Hiatt, III. 2001. Ergot alkaloid transport across ruminant gastric tissues. *J. Anim. Sci.* 79:542-549.
- Horton, G. M. J. and C. C. Burgher. 1992. Physiological and carcass characteristics of hair and wool breeds of sheep. *Small Rumin. Res.* 7:51-60.
- Hoveland, C. S., S. P. Schmidt, C. C. King, Jr., J.W. Odom, E. M. Clark, J. A. McGuire, L. A. Smith, H. W. Grimes, and J. L. Holliman. 1983. Steer performance and association of *Aremonium coenophialum* fungal endophyte on tall fescue pasture. *Agron. J.* 75:821-824.
- Jackson, F and R. L. Coop. 2000. The development of anthelmintic resistance in sheep nematodes. *Parasit.* 120:S95-S107.

- Jones, K. G. 2004. Trends in the U.S. sheep industry. Agriculture information bulletin number 787. <<http://usda.mannlib.cornell.edu/usda/ers/sheeptrends/aib787.pdf>>. Accessed 25 May 2013.
- Katahdin Hair Sheep International (KHSI). 2012. History of the Katahdin Breed. <www.katahdins.org>. Accessed 25 May 2013.
- Knights, M., N. Siew, R. Ramgattie, D. Singh-Knights, G. Bourne. 2012. Effect of time of weaning on the reproductive performance of Barbados Blackbelly ewes and lamb growth reared in the tropics. *Small Rumin. Res.* 103:205-2010.
- Lefcourt, A. M. and T. H. Elsasser. 1995. Adrenal responses of Angus x Herford cattle to the stress of weaning. *J. Anim. Sci.* 73:266-2676.
- Looper, M. L., S. T. Reiter, B. C. Williamson, M. A. Sales, D. M. Hallford, and C. F. Rosenkrans, Jr. 2010. Effects of body condition on measures of intramuscular and rump, endocrine factors, and calving rate of beef cows common bermudagrass or endophyte-infected tall fescue. *J. Anim. Sci.* 88:4133-4141.
- Malinowski, D. P. and D. P. Belesky. 2000. Adaptations of endophyte-infected cool-season grasses to environmental stresses: Mechanisms of drought and mineral stress tolerance. *Crop Sci.* 40:923-940.
- Marley, C. L., M. D. Fraser, W. J. Fisher, A. B. Forbes, R. Jones, J. M. Moorby, J. C. MacRae, and M. K. Theodorou. 2007. Effects of continuous or rotational grazing of two perennial ryegrass varieties on the chemical composition of the herbage and the performance of finishing lambs. *Grass and Forage Sci.* 62:255-264.
- Meyers., S. E., D. B. Faulkner, F. A. Ireland, and D. F. Parrett. 1999. Comparison of three weaning ages on cow-calf performance and steer traits. *J. Anim. Sci.* 77:323-329.
- Ness, K., J. Caldwell, K. Coffey, B. Shanks, D. Hubbell, III, A. Stewart, E. Backes, J. Tucker, C. Clifford-Rathert, and A. Wurst. 2012. Performance by fall-born calves weaned in the morning or evening using either fenceline or traditional weaning methods. *Arkansas Agri. Exper. Sta. Research Series* 606:31-33.
- Nihsen, M. E., E. L. Piper, C. P. West, R. J. Crawford, Jr., T. M. Denard, Z. B. Johnson, C. A. Roberts, D. A. Spiers, and C. F. Rosenkrans, Jr. 2004. Growth rate and physiology of steers grazing tall fescue inoculated with novel endophytes. *J. Anim. Sci.* 82:878-883.
- NOAA. 2013. Climatography of the United States. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days. National Oceanic and Atmospheric Administration. Natl. Climatic Data Center, Asheville, NC. <<http://www.ncdc.noaa.gov/land-based-station-data/climate-normals/1981-2010-normals-data>>. Access 19 June 2013.

- Ogunbameru, B. O., E. T. Kornegay, and C. M. Wood. 1992. Effects of evening or morning weaning and immediate or delayed feeding on postweaning performance of pigs. *J. Anim. Sci.* 70:337-342.
- Orgeur, P., N. Mavric, P. Yvone, S. Bernard, R. Nowak, B. Schaal, F. Levy. 1998. Artificial weaning in sheep: consequences on behavioural, hormonal and immune-pathological indicators of welfare. *Appl. Anim. Behav. Sci.* 58:87-103.
- Orihuela, A., E. Suarez, R. Vazquez. 2004. Effect of restricting suckling on the social bond between ewes and their 10-week-old lambs. *Livest. Prod. Sci.* 87:259-264.
- Owensby, C. E. 1973. Modified step-point system for botanical composition and basal cover estimates. *J. Range Manage.* 26:302-303.
- Popp, J. D., W. P. McCaughey, and R. D. H. Cohen. 1997. Grazing system and stocking rate effects on the productivity, botanical composition and soil surface characteristics of alfalfa-grass pastures. *Can. J. Anim. Sci.* 77:669-676.
- Porter, J. K. and F. N. Thompson, Jr. 1992. Effects of fescue toxicosis on reproduction in livestock. *J. Anim. Sci.* 70:1594-1603.
- Price, E. O., J. E. Harris, R. E. Borgwardt, M. L. Sween, and J. M. Connor. 2003. Fenceline contact of beef calves with their dams at weaning reduces the negative effects of separation on behavior and growth rate. *J. Anim. Sci.* 81:116-121.
- Realini, C. E., S. K. Duckett, N. S. Hill, C. S. Hoveland, B. G. Lyon, J. R. Sackmann, and M. H. Gillis. 2005. Effect of endophyte on carcass traits, meat quality, and fatty acid composition of beef cattle grazing tall fescue. *J. Anim. Sci.* 83:430-439.
- Rhodes, M. T., J. A. Paterson, M. S. Kerley, H. E. Garner, and M. H. Laughlin. 1991. Reduced blood flow to peripheral and core body tissues in sheep and cattle induced by endophyte-infected tall fescue. *J. Anim. Sci.* 69:2033-2043.
- Rogers, W. M., Roberts, C. A., J. G. Andrae, D. K. Davis, G. E. Rottinghaus, N. S. Hill, R. L. Kallenbach, and D. E. Spiers. 2011. Seasonal fluctuation of Ergovaline and total ergot alkaloid concentrations in tall fescue regrowth. *Crop Sci.* 51:1291-1296.
- Russel, A. J., J. M. Doney, and R. G. Gunn. 1969. Subjective assessment of body fat in live sheep. *J. Agric. Sci. (Camb.)* 72:451-454.
- Sharrow, S. H. 1983. Forage standing crop and animal diets under rotational vs. continuous grazing. *J. Range. Mange.* 36:447-450.
- Sharrow, S. H. and W. C. Krueger. 1979. Performance of sheep under rotational and continuous grazing on hill pastures. *J. Anim. Sci.* 49:893-899.

- Shauer, C. S., P. B. Berg, L. P. Anderson, D. Nuddel, T. C. Faller, D. M. Stecher, D. Pearson, and D. Drolc. 2006. Influence of Katahdin breeding on feedlot performance and carcass characteristics of finishing lambs. *Western Dakota Sheep and Beef Day*. 47:38-41.
- Schillo, K. K., L. S. Leshin, J. A. Boling, and N. Gay. 1988. Effects of endophyte-infected fescue on concentrations of blood prolactin in blood sera and the anterior pituitary and concentrations of dopamine and dopamine metabolites in brains of steers. *J Anim Sci*. 66:713-718.
- Schwulst, F. J. and L. C. Martin. 1995. Performance of lambs sired by Rambouillet, Tunis, Romanov, and Katahdin rams-three lamb crops. *Kansas Sheep Res.*728:1-7.
- Stookey, J. M., Schwartkopf-Genswein, K. S., Waltz, C. S., Watts, J. M. 1997. Effects of remote and contact weaning on behaviour and weight gain of beef calves. *J. Anim. Sci*. 75(Suppl. 1), 157.
- USDA-NASS. 2011a. United States Department of Agriculture-National Agricultural Statistic Service. <<http://usda01.library.cornell.edu/usda/nass/SheeGoat//2010s/2011/SheeGoat-01-28-2011.pdf>>. Accessed 25 May 2013.
- USDA-NASS. 2013a. United States Department of Agriculture-National Agricultural Statistic Service. <<http://usda01.library.cornell.edu/usda/nass/FarmLandIn//2010s/2013/FarmLandIn-02-19-2013.pdf>>. Accessed 25 May 2013.
- USDA-NASS. 2011c. United States Department of Agriculture-National Agricultural Statistic Service. <<http://usda01.library.cornell.edu/usda/nass/MeatAnimPr//2010s/2011/MeatAnimPr-04-28-2011.pdf>>. Accessed 25 May 2013.
- USDA-NASS. 2013b. United States Department of Agriculture-National Agricultural Statistic Service. <<http://www.usda.gov/nass/PUBS/TODAYRPT/shep0213.pdf>>. Accessed 25 May 2013.
- Vanimisetti, H. B., S. P. Greiner, A. M. Zajac, and D. R. Notter. 2004. Performance of hair sheep composite breeds: Resistance of lambs to *Haemonchus contortus*. *J. of Anim. Sci*. 82:595-604.
- Vanimisetti, H. B., D. R. Notter, and L. A. Kuehn. 2007. Genetic (co)variance components for ewe productivity traits in Katahdin sheep. *J. Anim. Sci*. 85:60-68.
- Warner, J. R. and S.H. Sharrow. 1984. Set stocking, rotational grazing and forward rotational grazing by sheep on western Oregon hill pastures. *Grass and Forage Sci*. 39:331-338.

- Wildeus, S. K. E. Turner, and J. R. Collins. 2007. Growth, intake, diet digestibility, and nitrogen use in three hair sheep breeds fed alfalfa hay. *Small Rumin. Res.* 69:221-227.
- Wildeus, S and A. M. Zajac. 2005. Gastrointestinal parasitism in hair sheep and meat goat breeds grazing naturally infected pastures. *Sheep and Goat Res. J.* 20:42-46.